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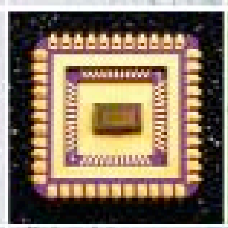
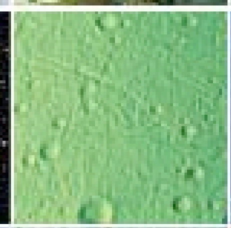
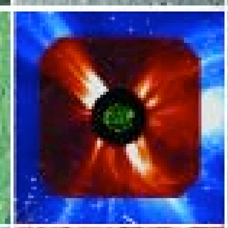
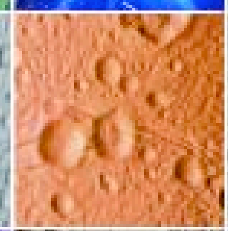




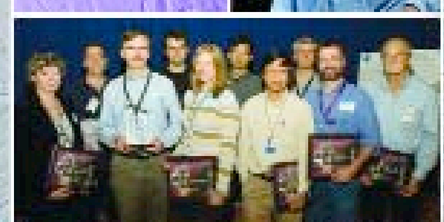




R&D Achievements

Collaboration + Innovation = Mission Success

A Report on the FY 2008 Internal Research and Development Program



Goddard Space Flight Center

08

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National Aeronautics and Space Administration

Collaboration + Innovation = Mission Success

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08 Mission Successes

Message from the Chief Technologist

Collaboration + Innovation = Mission Success

Three years ago, we revamped our Internal Research and Development (IRAD) program to make it more opportunity focused and better aligned with the Center's core lines of business. Our goal was simple. We wanted to give our technologists a competitive advantage when they competed for already-identified mission and instrument opportunities.

That realignment — coupled with an increased emphasis on collaboration among our technologists — is paying off.

In FY 2008, 17 technology teams won more than $73 million in new missions or secured follow-on funding from other research programs to further advance their work. This level of funding is unprecedented and is testimony to the wisdom of our strategic realignment. I could not be more pleased. Winning new work is the primary goal of our IRAD program.

It is not, however, the only reason we fund promising new technologies, nor is it the only measure of our success. Of the 101 proposals we funded in FY 2008, many validated their technologies in aircraft demonstrations, created much-needed new facilities and testbeds, and forged partnerships that increased their chances of winning new work in the future.

Our IRAD-funded teams also formulated concepts for future science and exploration missions. They filed patent applications. They published papers and participated in important decision-making panels. They created educational programs to nurture the Agency's future scientists and engineers. In short, they took the steps necessary to ultimately realize success in areas vital to NASA's continued success.

Peter M. Hughes, Chief Technologist

Our diligence in making sure that the proposals we funded were aligned with the strategic direction of the Center and the Agency as a whole, while encouraging our innovators to collaborate where possible, contributed to our mission success. In FY 2008, collaboration, coupled with innovation, truly resulted in mission success.

Strategic Investment Areas in FY 2008

To keep the IRAD program focused on technologies deemed important to the Center and the continued employment of the Center's high-caliber workforce, the Office of the Chief Technologist awarded 101 research proposals under the following focus areas:

Astrophysics

Astrophysics is one of GSFC's lines of business. It focuses on missions and technologies aimed at answering: How do galaxies, stars, and planetary systems form and evolve? What is the diversity of worlds beyond our own solar system? Which planets might harbor life? What happens to space, time, and matter at the edge of a black hole?

Earth Science

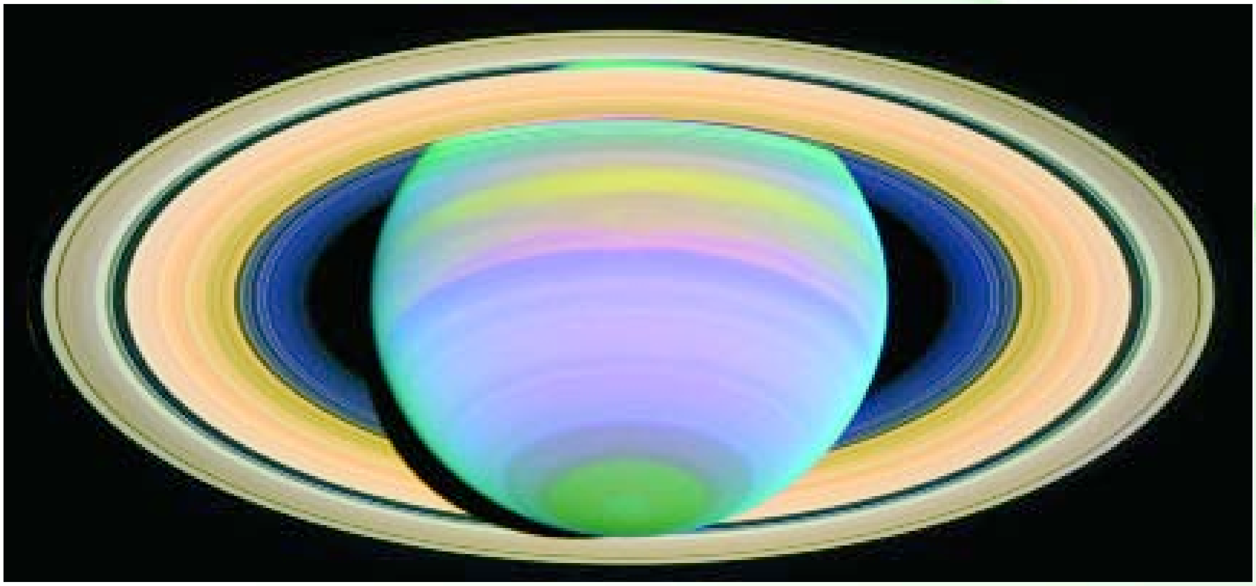
Developing technologies needed to observe and understand changes in Earth's climate system is the focus of this GSFC line of business. Technologies include state-of-the-art remote sensors and aircraft-based and surface-based observational platforms.

Education

Education is not a GSFC line of business. However, the Office of the Chief Technologist provides seed funding to those educational programs that are closely aligned with NASA's strategic plan and have potential to secure external funding to fully carry out the activities in support of GSFC's science and exploration pursuits.

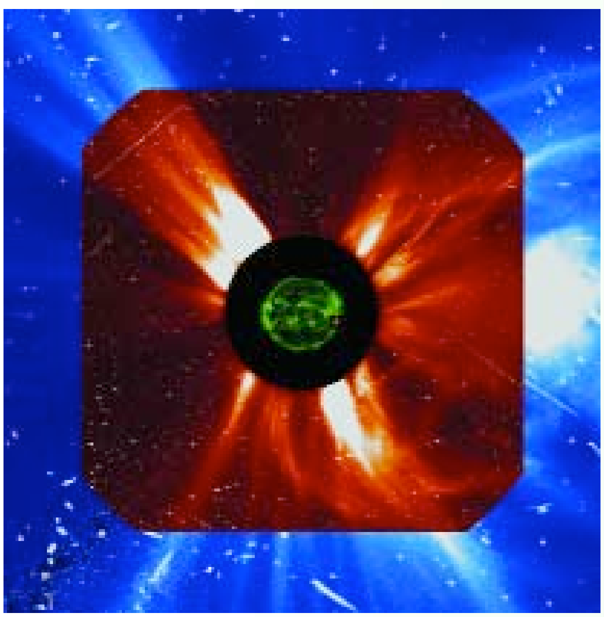
Exploration Systems and Technologies

Technologies needed for future exploration missions to the Moon and Mars fall under this line of business. Such systems could include highly advanced sensors and platforms, autonomous rendezvous and docking systems, miniaturized instrumentation, imaging, and applied science for exploration.



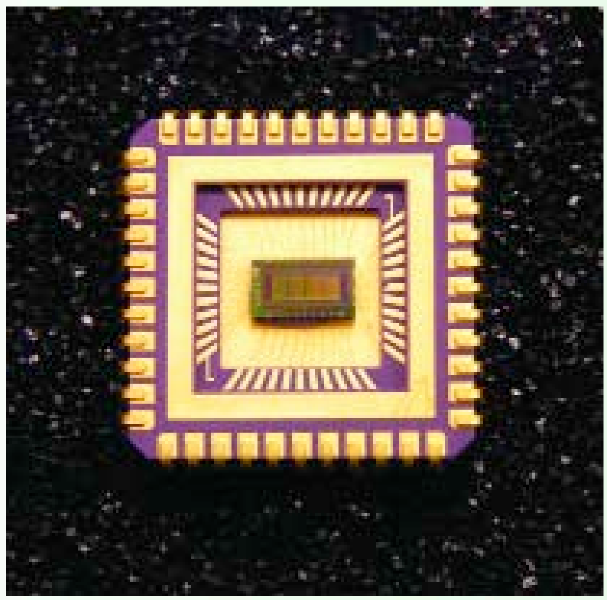
Planetary and Lunar Science

The planetary and lunar science line of business supports new scientific measurements to explore the solar system. Primary research areas include instruments for landers and orbiting spacecraft.



Heliophysics

Solar structure and magnetic activity, solar wind, solar disturbances, and the effects on Earth's upper atmosphere are some of the research areas that fall under the heliophysics line of business. Wavelength coverage spans gamma rays to microwaves and includes particles and fields.



Strategic Crosscutting Technologies

Some technologies, including electronics, orbit determination, and propulsion, to name a few, could benefit many GSFC lines of business. This focus area addresses those that address multiple strategic objectives.

Significant Achievements: New Missions and Follow-On Funding

The primary purpose of the IRAD program is assuring the Center's competitive edge and winning new work in areas deemed strategically important to GSFC (see Strategic Investment Areas in FY 2008, page 2). Although our program uses many metrics to gauge effectiveness, securing new business or follow-on funding is the most tangible measure.

FY 2008 was a particularly good year for IRAD-funded principal investigators. Seventeen IRAD-funded teams netted more than $73 million in new business, successfully leveraging R&D seed funding to further advance their technologies.

Here we spotlight many of those significant accomplishments and the sources of follow-on funding.

Explorer Program Mission of Opportunity

Soft X-ray Spectrometer (SXS)

In late June, NASA selected GSFC's Soft X-ray Spectrometer (SXS) team to build the $44 million instrument for Japan's Astro-H mission slated to fly in 2013. The instrument, which will probe the motion of matter in extreme environments, offers significant improvements over previously flown spectrometers, particularly in the areas of detector performance, cooling technologies, and collecting area — enhancements made possible by GSFC's previous R&D investments. Because of its success leveraging R&D funds and winning an important instrument-development opportunity, the team received the FY 2008 "IRAD Innovator of the Year" award (see story to the right).

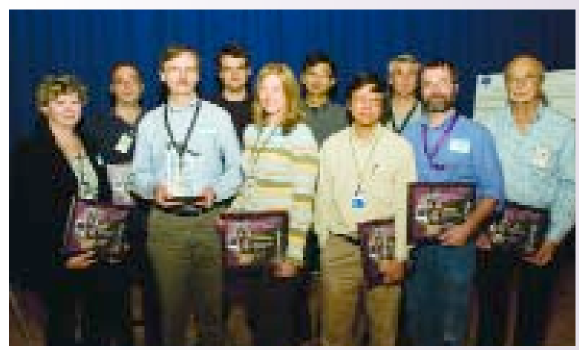
"Certainly, the support we received through Goddard's Internal Research and Development (IRAD) and other programs contributed to our proposal win and our ability to build an enhanced instrument."

— Principal Investigator Richard Kelley

SXS Team Wins IRAD Innovator of the Year Award

Each year, the Office of the Chief Technologist bestows its "IRAD Innovator of the Year" award to technologists who exemplify the best in R&D. This year, that honor went to Principal Investigator Richard Kelley and his Soft X-ray Spectrometer (SXS) team.

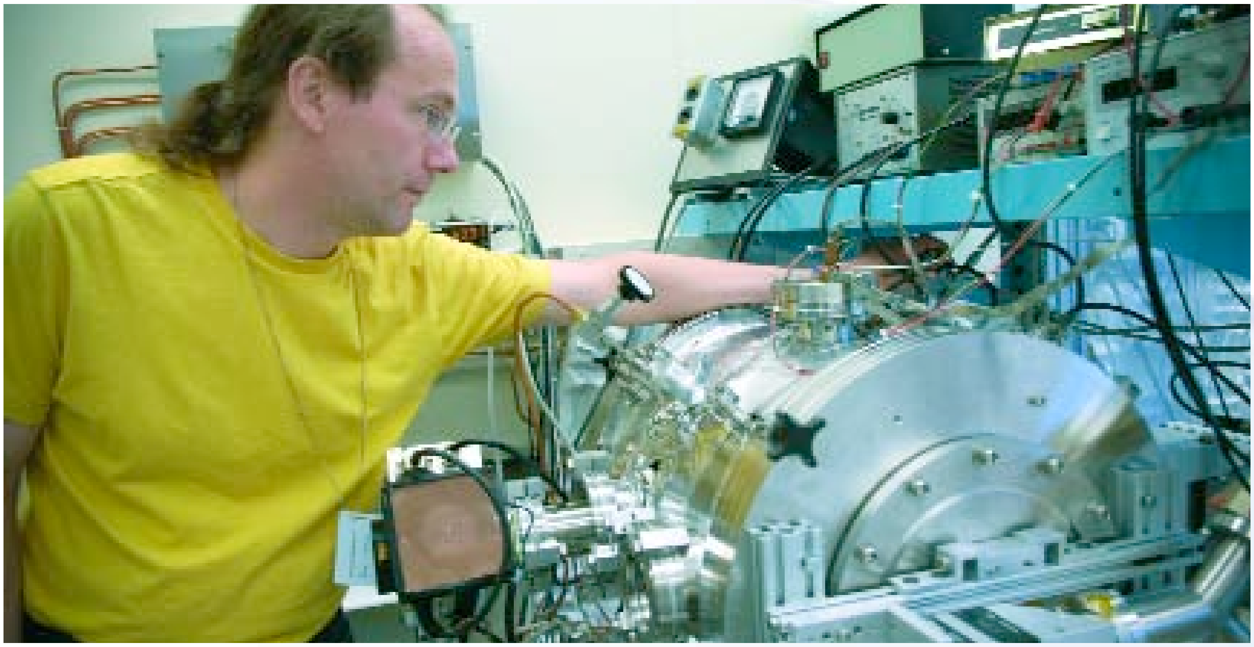
The SXS team was chosen because of its success leveraging R&D funds to enhance instrument capabilities, which resulted in the team winning $44 million under the Agency's Explorer Program Mission of Opportunity solicitation to build the next-generation instrument for the Astro-H mission, which the Japan Aerospace Exploration Agency plans to launch in 2013. The spectrometer will probe the motion of matter in extreme environments, investigate the nature of dark matter on large scales, and explore how galaxies and clusters of galaxies form and evolve.



The SXS team includes (from left to right): Christine Jhabvala, Nicholas Costen, Richard Kelley, Samuel J. Moseley, Caroline Kilbourne, Takashii Okajima, Yang Soong, Peter Shirron, F. Scott Porter, and Peter Serlemitsos.

Though similar in many respects to the X-Ray Spectrometer (XRS) that flew on Japan's Suzaku Observatory in 2005, the new instrument will offer greater capabilities particularly in the areas of detector performance, cooling technologies, and collecting area — enhancements made possible in part by Goddard's R&D investment programs.

In addition to Kelley, members of the SXS team include Nicholas P. Costen, Christine Jhabvala, Caroline Kilbourne, Samuel J. Moseley, Takashi Okajima, F. Scott Porter, Peter Serlemitsos, Peter Shirron, and Yang Soong.



Goddard scientist Phil Deines-Jones and his colleague, Kevin Black, used R&D funding to develop the world's first time-projection chamber polarimeter to measure the polarization of X-ray light.

Phase-A Small Explorer Study

Gravity and Extreme Magnetism SMEX (GEMS)

Until now, scientists were unable to effectively measure the polarization of X-ray light to learn how fast black holes rotated and how their spin rates affected the curvature of space-time. Their efforts were hampered by inadequate instrument sensitivity and difficulty capturing enough X-ray photons. With support from the IRAD program over the past 5 years, however, GSFC technologists developed a new technique for measuring polarization, building the world's first time-projection chamber polarimeter. As a result of these efforts, the Gravity and Extreme Magnetism SMEX team, led by Principal Investigator Jean Swank, won $750,000 to carry out a detailed mission concept study of a Small Explorer-class mission to provide these never-before-obtained measurements. Of the six missions selected for Phase-A studies, the Agency will select two in FY 2009 for full development. (Investment area: Astrophysics)

> *"It's the most sensitive technique that anyone knows of for doing this type of science. It's also a unique Goddard capability."*
>
> *— IRAD Principal Investigator and GEMS Team Member Phil Deines-Jones*

Astrobiology Instrument Development (ASTID) Program

Advanced Planetary Atmosphere-Magnetosphere Mass Spectrometer

Principal Investigator Ed Sittler used IRAD funds to develop key technologies for the Advanced Planetary Atmosphere-Magnetosphere Mass Spectrometer, and in doing so, secured $1.2 million from NASA's ASTID program to ultimately develop an instrument that could fly on a mission to Jupiter's Europa/Ganymede or Saturn's Titan/Enceladus. (Investment area: Planetary and Lunar Science)

Compact Lidar for High-Resolution Measurements of Trace Gases

Remotely detecting trace gases from orbit advances planetary science. On Earth, methane is a strong greenhouse gas. On Mars, methane, as well as those of other biogenic molecules, could indicate the presence of organic life. Using IRAD funding in FY 2007 and FY 2008, GSFC Principal Investigator Haris Riris leveraged work done in laser altimetry, space lidar, laser spectroscopy, and precise laser metrology to develop a breadboard sounder that received nearly $755,000 in ASTID funding. The follow-on funding will help the team advance the technology's state of readiness, which could lead to the award of future missions. (Investment area: Planetary and Lunar Science)

Volatile Analysis by Pyrolysis of Regolith (VAPoR)

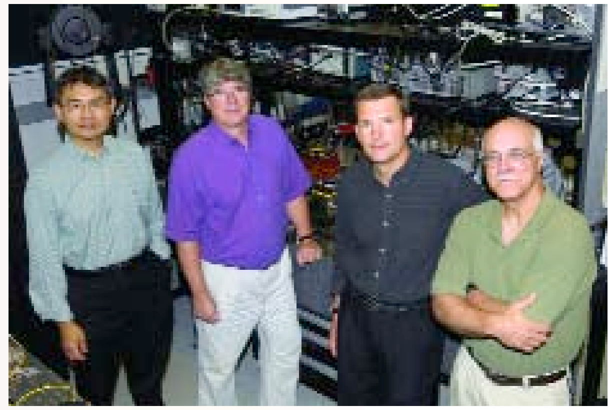
Previous lunar missions have detected high concentrations of hydrogen in permanently shadowed areas of the Moon's polar regions. However, NASA has yet to perform in situ measurements to determine the presence of water-ice and other volatiles. In FY 2008, GSFC's VAPoR team, led by Principal Investigator Daniel Glavin, finished building and testing a breadboard of a miniaturized pyrolysis mass spectrometer that could characterize the hydrogen. These advances helped the team secure $1.2 million in ASTID funding to develop an instrument prototype, which could one day find a flight opportunity to the Moon or other solar-system bodies. (Investment area: Planetary and Lunar Science)

"The IRAD funding was critical in winning the ASTID proposal. The synergy of the IRAD and outside efforts, such as ASTID, will ensure continued success in our trace gas-sensing program."

— Principal Investigator Haris Riris

Principal Investigator Daniel Glavin received $1.2 million in NASA funding to develop an instrument prototype that could characterize the high concentrations of hydrogen in the permanently shadowed areas of the Moon's polar regions.

Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP)



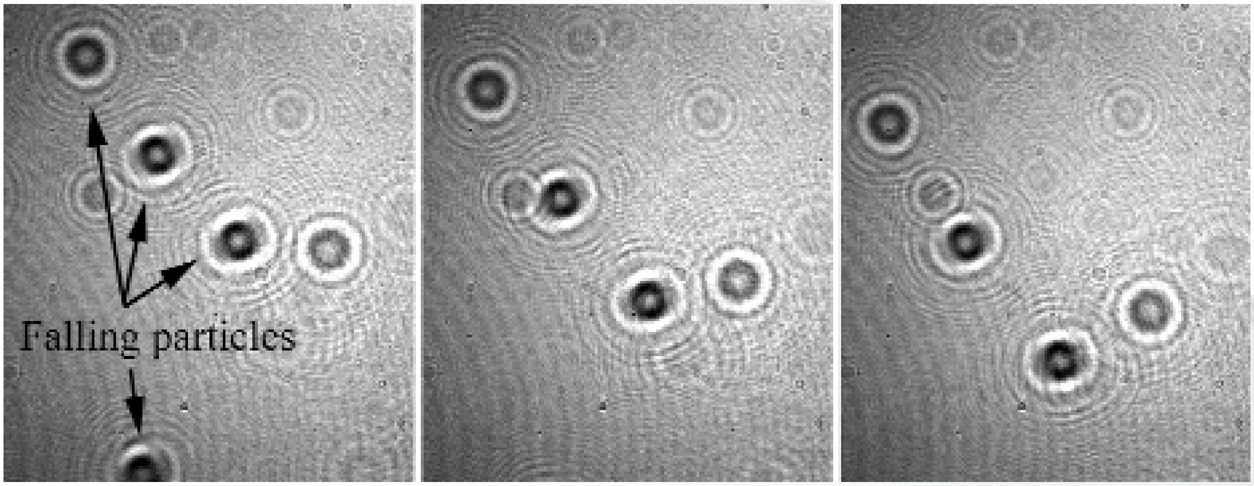
Goddard technologists (from left t right) Tony Yu, Bill Heaps, Bill Abshire, and Chuck McClain won Instrument Incubator Program funding to advance the technology-readiness levels of different Earth-observing instruments.

Carbon-Dioxide Measurements

Principal Investigators James Abshire and William Heaps won $2.55 million and $1.87 million, respectively, in IIP funding to develop two different laser techniques for measuring carbon dioxide, a leading greenhouse gas in the atmosphere. Both instrument prototypes, which previously received IRAD seed funding, would satisfy requirements of the Active Sensing of CO2 Emissions over Nights, Days, and Seasons mission, proposed by the National Research Council in its first-ever Decadal Survey of Earth-observing missions. (Investment area: Earth Science)

Swath-Mapping Laser Altimetry Demonstration

ESTO also awarded $3.44 million to IRAD Principal Investigator Tony Yu, who is developing a swath-mapping laser altimeter that would measure how long it takes for photons in a laser pulse to hit the ground, reflect, and travel back to the instrument, thereby providing topographic and vegetation data. Unlike other laser altimters, Yu's instrument concept includes at least 16 laser spots, each measuring only 5 meters in diameter. With multiple laser beams, the instrument would allow simultaneous measurements over a larger geographic area. The follow-on funding is a step toward realizing the ultimate goal of a 1,000-beam swath mapping of Earth's surface, as recommended by the National Research Council's Lidar Surface Topography mission. (Investment area: Strategic Crosscutting Capabilities)



During a field campaign in 2007, Principal Investigator Brent Bos used his Large Depth-of-Field Particle Image Velocimeter to capture these images of dust particles as small as 10 microns (related story lower right).

Ocean Radiometer for Carbon Assessment (ORCA)

Building on work that GSFC scientists pioneered in the development of other ocean color sensors — particularly the Sea-viewing Wide Field-of-view Sensor and the Moderate-resolution Imaging Spectroradiometer — Principal Investigator Chuck McClain is developing ORCA under IIP funding. The next-generation ocean radiometer will measure marine photosynthesis, which is key to the carbon cycle and ocean food chain. McClain attributed his $3.35 million IIP award to past IRAD investments, which helped jumpstart his research. (Investment area: Earth Science)

"The support from Goddard IRAD was a key factor in our start and in some key technical areas."

— Principal Investigator James Abshire

Lunar Advanced Science and Exploration Research (LASER)

Lunar Potential Determination Using Apollo-Era Data and Modern Measurements and Models

IRAD investments in lunar dust-characterization studies contributed to Principal Investigators Michael Collier and Bill Farrell receiving $540,000 in LASER funding to combine Apollo-era data with modern measurement techniques to determine the surface potential at many different points on the lunar surface. These results will be used to calibrate a comprehensive model for the lunar potential. (Investment area: Planetary and Lunar Science)

Planetary Science Division Announcement of Opportunity

Mapping Lunar Surface Electric Field sand Characterizing the Exospheric Dust Environment

In related lunar surface studies, principal investigators built a model of the surface potentials at the cratered regions of the Moon's South Pole, resulting in GSFC scientist Tim Stubbs winning a 3-year, $370,000 NASA Planetary Science Division award to apply this model to Lunar Reconnaissance Orbiter (LRO) data as a LRO participating scientist. (Investment area: Planetary and Lunar Science)

Exploration Technology Development Program (ETDP)

Large Depth-of-Field Particle Image Velocimeter (PIV)

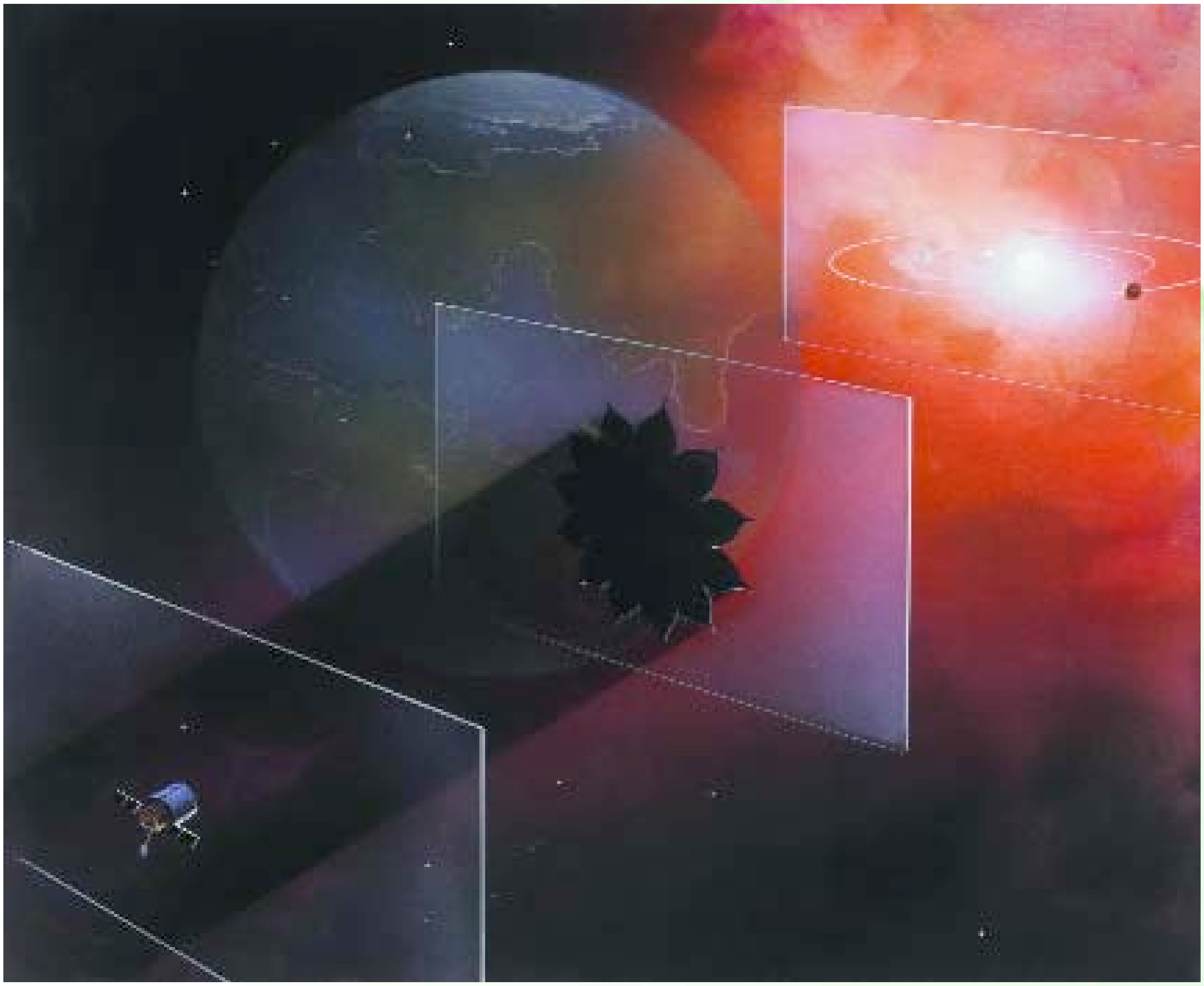
In yet another effort to better understand the Moon's dust environment, IRAD Principal Investigator Brent Bos is developing a prototype instrument, the PIV, which would give scientists an unprecedented ability to measure particle sizes, concentrations, and velocities. In FY 2008, ETDP invested $15,000 in the effort, while IRAD funding supported the development of algorithms to reduce the size of the instrument's large datasets. (Investment area: Exploration Systems and Technologies)

Advanced Mission Concept Studies

Technologist Scott Barthelmy used IRAD funds to advance a next-generation cadmium-zinc-telluride detector array. The instrument prototype also would be useful for detecting nuclear material hidden in shipping containers and trains.

Energetic X-ray Imaging Survey Telescope

In 2008, NASA awarded an Advanced Mission Concept Study to the Energetic X-ray Imaging Survey Telescope (EXIST) team, thanks in part to past IRAD investments in a next-generation cadmium-zinc-telluride (CZT) detector array that could be used on the mission and others. GSFC received $150,000 toward the study and a leading GSFC scientist, Neil Gehrels, was named a co-principal investigator on the EXIST study. (Investment area: Astrophysics)



This artist's concept shows the proposed New Worlds Observer and its giant sunshade, which would fly in formation with the telescope to block starlight and help reveal the presence of planets within a star's habitable zone.

Astronomical Search for Exoplanets

An FY 2008 IRAD also contributed to GSFC receiving $700,000 to carry out concept studies for three potential extrasolar planet-finding missions — the New Worlds Explorer, Advanced Technology Large-Aperture Space Telescope, and eXtrasolar Planet Characterization mission. The studies will play a role in what the National Research Council recommends as the priorities in its upcoming Astronomy and Astrophysics Decadal Survey. (Investment area: Astrophysics)

Applied Physics Research and Analysis (APRA)

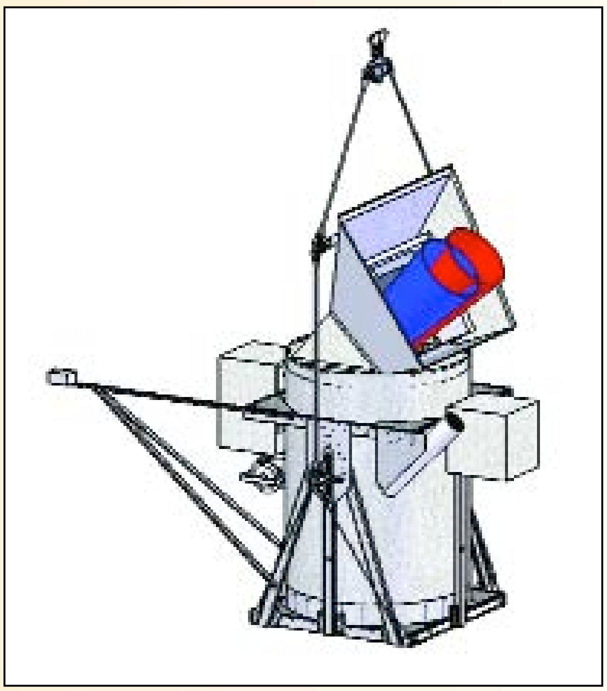
Metallic Magnetic Microcalorimeter Arrays

IRAD Principal Investigator Wen-Ting Hsieh is developing a new technique to produce microcalorimeter arrays, a detector technology that converts incoming X-ray photons into heat to reveal the physical properties of the object emitting the light. Her IRAD-funded work resulted in an APRA award, valued at more than $1 million, which she hopes will put her in a good position to ultimately create a 1,000-pixel array and a mission opportunity with the International X-ray Observatory (formerly known as Constellation-X). (Investment area: Astrophysics)

Research Opportunities In Space and Earth Sciences (ROSES)

Primordial Inflation Polarization Explorer (PIPER)

Efforts to advance technologies needed to measure the polarization of the background radiation created during the Big Bang were rewarded with a $5.86 million ROSES award in FY 2008. The funding, which principal investigators attributed to multi-year IRAD awards, will support the development of PIPER, a balloon payload that will fly four times beginning in 2013. Its mission: Search for the gravity wave signal of cosmic inflation, a theory that postulates that the universe expanded far faster than the speed of light after its creation. The work could lay the technological foundations for even more sophisticated missions in the future. (Investment area: Astrophysics)



This artist's rendition shows the Primordial Inflation Polarization Explorer, a balloon-borne instrument that will look for the gravity wave signal of cosmic inflation, a theory that postulates that the universe expanded far faster than the speed of light after its creation.

Innovative Partnerships Program (IPP)

Wavelength Division Multiplexed Fiber Laser for Mapping Laser Altimetry

The future looks bright for a new technology that could extend the Center's laser altimetry capability from the single-channel profiling approach used in ICESat to a next-generation design that allows swath mapping with more than 30 laser beams. Principal Investigator Jeffrey Chen, who has won a U.S. patent for his work, received $250,000 from the Innovative Partnerships Program Office to work with a Virginia-based company, Fibertek, to advance the technology, which would benefit future Earth-observing and planetary missions. (Investment area: Earth Science and Planetary and Lunar Science)

IRAD Principal Investigator Cathy Long is working with Northrop Grumman under a Space Act Agreement that allows the two to share knowledge and resources to develop radar technologies for future NASA missions.

Radar Initiatives in Collaboration with Northrop Grumman

Through IRAD funding, Principal Investigator Cathy Long was able to define and develop a Space Act Agreement with Northrop Grumman that allows the two organizations to share knowledge and resources in an effort to demonstrate radar technologies specifically for future NASA missions. The collaboration has resulted in a $190,000 IPP award and resources from the GFSC-led Soil-Moisture Active Passive mission. (Investment area: Earth Science and Planetary and Lunar Science)

Other Notable IRAD Achievements

R&D investment programs are high-risk endeavors. In some cases, the research does not yield the expected outcome or result. In other cases, the principal investigator achieves precisely what he or she set out to accomplish. Here we spotlight a few IRAD-funded efforts that could result in Goddard winning new work in the future and help NASA to carry out its science and exploration missions.

Astrophysics

Nanostructure Mirror for Diffraction Suppression

The diffraction of light limits the resolving power of all imaging systems, making it difficult to isolate the image of faint objects near bright objects. Under this IRAD, the goal was to develop a mirror geometry using nanostructures to suppress the classical "Airy" rings that limit many scientific observations. A prototype was completed in December 2008, and work will continue in FY 2009. If successful, the technology could improve existing imaging techniques and enhance the capabilities of astronomical telescopes. Principal Investigator: John Hagopian

Absolute Spectrum Polarimeter (ASP) Technology Risk Reduction

ASP is a concept for measuring the gravity wave signal of inflation shortly after the Big Bang. In FY 2008, research centered on raising the technology-readiness levels of several important subsystems, including precision motion control for the cryogenic interferometer, large-area polarization-sensitive detectors, and the blackbody calibrator. The IRAD-funded research will benefit the principal investigator in a related effort to develop the $5.86 million Primordial Inflation Polarization Explorer (PIPER), a balloon experiment that NASA funded in FY 2008. PIPER will begin flying in 2013 (see page 10 for details). Principal Investigator: Al Kogut

Thermally Driven Pump for Sub-Kelvin Magnetic Refrigerator

The Sub-Kelvin Active Magnetic Regenerative Refrigerator is a new type of cooling technology, which could be used to cool next-generation infrared bolometers and X-ray microcalorimeters needed for the International X-ray Observatory and other missions. With FY 2008 IRAD funding, research centered on developing an efficient,

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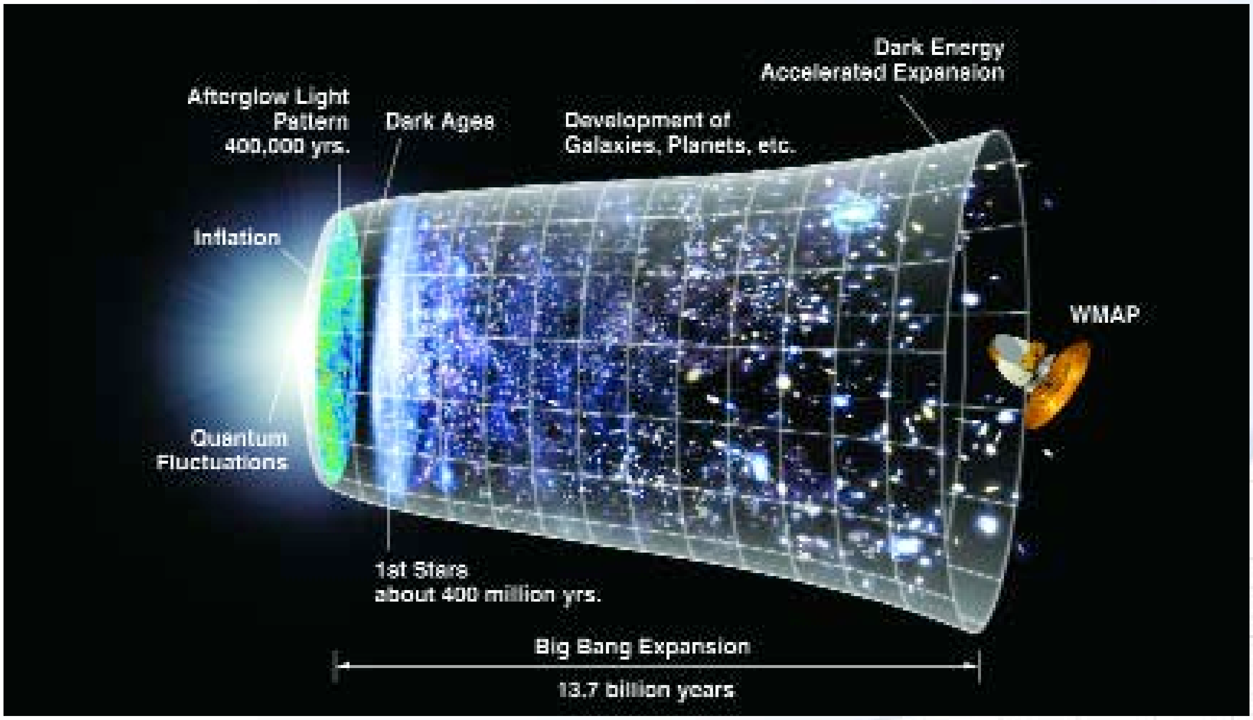


This graphic shows the timeline of the universe. Although the universe has expanded gradually over most of its history, scientists believe that it grew from subatomic scales to the astronomical in a fraction of a second after its birth. GSFC scientist Al Kogut is developing several important subsystems for an instrument that would measure the gravity wave signal of this rapid inflation.

Thermally Driven, continued from page 11

thermodynamically reversible pump that could pump a mixture of helium 3 and helium 4 in a temperature range below 1.7 Kelvin. The Center's Office of Patent Counsel filed for a provisional patent for the technology. Principal Investigator: Franklin Miller

Earth Science

RFI Mitigation for Microwave Radiometers

Radio frequency interference (RFI) has corrupted microwave radiometer measurements at specific frequencies for nearly 30 years. NASA's decision to move forward with the Soil Moisture Active Passive (SMAP) mission made RFI mitigation urgent. With IRAD funding, the principal investigator installed GSFC-developed receivers on an aircraft to collect data over North America. His team is now analyzing the data to determine the level of interference and determine possible mitigation techniques, including the possible use of computer algorithms. Principal Investigator: Jeffrey Piepmeier

Microbolometer Imaging of Polar Winds from Iridium-2

Collaborating with Iridium LLC, Raytheon, and the Joint Center for Satellite Data Assimilation, principal investigators used the Center's Instrument Design Lab to design mass-production imagers to observe polar winds and improve weather forecasts. The IRAD study showed that the technology could track polar winds in real time and significantly improve medium-range weather forecasts in the next decade. Iridium used the design to respond to a National Oceanic and Atmospheric Administration call for proposals for commercial satellites to carry out environmental observations. Principal Investigator: Dennis Chesters

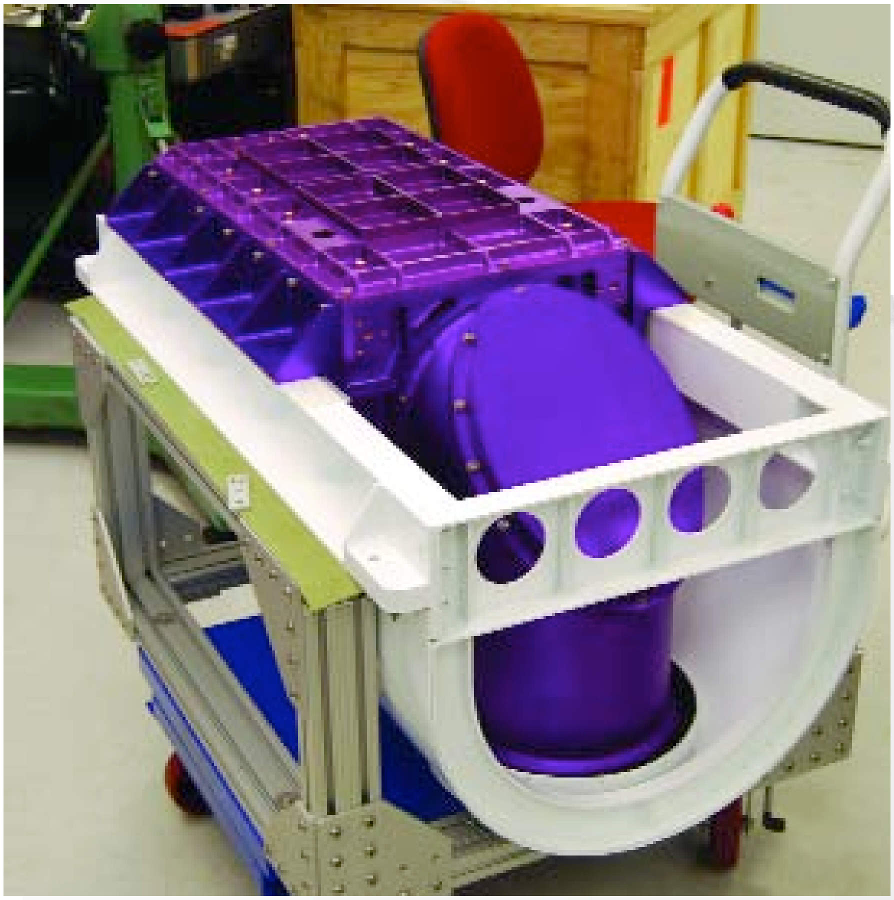
SIRICE Technology Development

NASA Headquarters has committed to supporting ER-2 test flights of a GSFC-developed airborne ice-measurement instrument in the summer of 2009 — tests needed to further refine the Submillimeter and InfraRed Ice Cloud Experiment, a next-generation radiometer that could fly on the proposed Aerosol-Cloud-Ecosystems mission. Principal Investigator: David Starr

Atmospheric scientist David Starr has gotten NASA support to fly an ice-measurement instrument aboard high-altitude spacecraft in the summer of 2009. The flight opportunities will help refine the Submillimeter and InfraRed Ice Cloud Experiment proposed for a next-generation Earth-observing mission.

Wind Lidar Observation Impact Studies

As part of a coordinated effort with another IRAD-funded project (see below), the principal investigator assimilated wind lidar measurements taken during a campaign in 2003 into the GEOS-5 atmospheric data assimilation system to test their impact on numerical weather forecasts out to days. The project is aimed at boosting support for the Global Winds Explorer mission, a Decadal Survey-recommended mission for 2016, and contributing to an Observing System Simulation Experiment (OSSE) that will guide future wind lidar mission decisions. Principal Investigator: Ron Gelaro



The Cloud Physics Lidar (CPL) is similar to the CPL that GSFC developed for high-altitude aircraft, except for one important distinction: This IRAD-funded instrument specifically will fly on unmanned aerial vehicles. In FY 2008, the team finished the instrument's assembly in preparation for installation and demonstration aboard a Global Hawk II.

Observation Simulation for Design of the Global Winds Explorer (GWE)

Another IRAD team developed an observation simulator, which is a component of an Observing System Simulation Experiment (OSSE) now being developed by the Global Modeling and Assimilation Office. Particularly, the simulator will allow scientists to evaluate the impact of GWE measurements on weather forecasts. Recommended by Decadal Survey, GWE is slated to fly in 2016; however, GSFC wants to further justify the mission through simulations and possibly advance the mission's schedule. Principal Investigator: Matt McGill

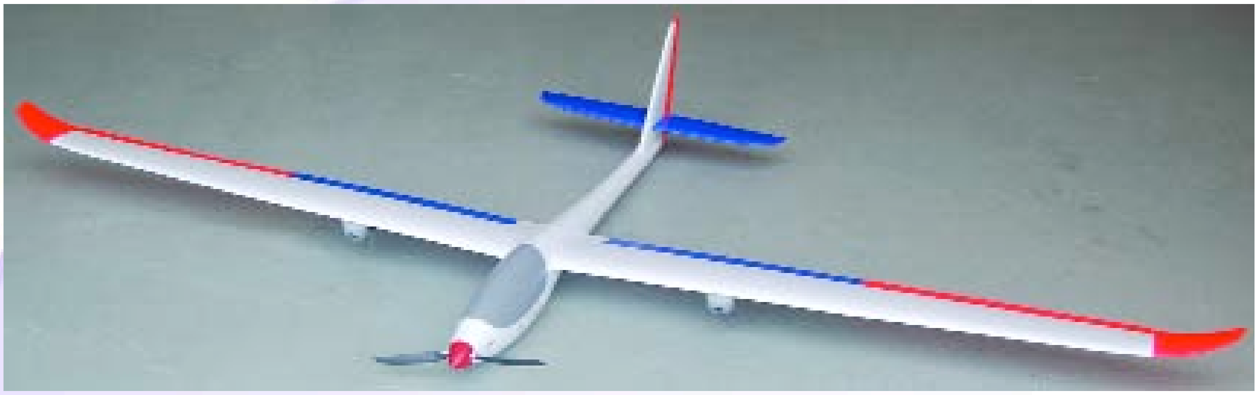
Geostationary Earth Observatory-Coastal and Air Pollution Events (GEO-CAPE)

GEO-CAPE, which would measure atmospheric chemistry, ocean biogeochemistry, and terrestrial biophysics, is a Decadal Survey-recommended mission that would observe the Earth from a geostationary orbit. Under this IRAD, the principal investigator began studies to ultimately make the mission smaller, lighter, and more affordable, and in doing so, better prepare the Center to ultimately lead the mission. Principal Investigator: S. Randolph Kawa

Improved Microwave Radiometer Receiver

The principal investigator carried out and tested systems and initial radio-frequency microstrip board designs for a new microwave radiometer that would operate in the C-band. Given the commonalities between this effort and the Soil Moisture Active Passive (SMAP) mission, SMAP will fund final design and test efforts. Principal Investigator: Kevin Horgan

Education



Ted Miles and Geoff Bland developed this prototype airplane, which the pair will use to teach techniques for building and integrating instruments for unmanned aerial vehicles. The effort is part of an IRAD-supported educational effort at the University of Maryland-Eastern Shore.

NASA/Salish Kootenai College Engineering Partnership

This IRAD funded the third year of a partnership with Salish Kootenai College, a tribal college located in Montana that serves the Confederated Salish and Kootenai tribes. Its goal is to provide NASA engineering expertise to help establish an accredited B.S. in Computer Engineering, the first four-year engineering program offered by any of the 34 tribal colleges in the U.S. As a result of this support, the college produced a prospectus and other documentation required for academic accreditation. Lead: James Jackson

Airborne Science Training Initiative (ASTI) AeroTech Program

In collaboration with the University of Maryland-Eastern Shore, Wallops Flight Facility engineers helped students develop several imaging systems for unmanned aircraft systems (see photo above). A change in Federal Aviation Administration rules prevented the students from flying their designs, but efforts are afoot to obtain these approvals. The program has created a lasting training and research capability at the school. Lead: Geoff Bland

Mission Management Initiative for Solar System Exploration

Under this IRAD, the principal investigator partnered with the Virginia Space Grant Consortium to provide university students with an understanding of the life cycle of a NASA mission, from concept to operations. The initiative provided training to three GSFC/Wallops mission managers and 20 Virginia Tech students, who ultimately flew a balloon experiment. Many of the students also interned at GSFC or continued onto graduate school.
Lead: Jessica McCarthy

The Mission Management Initiative for Solar System Exploration, a program that received IRAD seed funding in FY 2008, trained 20 Virginia Tech students who learned about the life cycle of a NASA mission, from concept to operations.

Exploration Systems and Technologies

Long-Term Cryopropellant Storage

GSFC's efforts to leverage its expertise with long-life and dual-cryogen systems to develop a subscale cryo-propellant system experienced a first in FY 2008. Engineers developed what they believe is the largest composite structure for spaceflight applications — a stiff, lightweight carbon-composite thermal shield to replace the original aluminum shield. The team also used IRAD funds to develop technologies needed to operate a thermodynamic vent system. The ultimate goal is to demonstrate a cryogenic-fuel storage system that NASA could use to power its Constellation suite of vehicles and increase the payload capacity of its transportation system. Principal Investigator: Ed Canavan

Cryogenic Hydrogen Radiation Shield

Between the Apollo 16 and 17 missions, a solar particle event occurred that could have resulted in an overexposure of radiation to astronauts had they been on the lunar surface at the time. Protecting future human explorers from similar events is the purpose of this IRAD study. Because hydrogen is the most mass effective material for radiation shielding, the principal investigator analyzed the thermal and structural design of a cryogenic hydrogen radiation shield for an Altair Ascent module. The design provides a basis for comparing its performance against polyethylene shields. Principal Investigator: Shuvo Mustafi

Moon Portable Electrostatic Detector (MOPED)

The principal investigator has made significant progress testing several components needed to develop a pencil-sized, miniaturized electrometer that would detect surface charging on spacesuits and equipment, giving astronauts real-time readings of their static charge as well as those of the equipment they are handling. Principal Investigator: Telana Jackson

Planetary and Lunar Science

High-Performance Photoreceivers for Interferometric Metrology

IRAD funding gave the principal investigator a head-start on efforts to build a custom photoreceiver that meets requirements of the proposed Laser Interferometer Space Antenna, a constellation of spacecraft that will search for gravitational waves, including those generated by the Big Bang. In FY 2007, the principal investigator received a 3-year, $450,000 award from the Astrophysical Theory and Fundamental Sciences program to build the detectors. The FY 2008 IRAD assured continued NASA support. Principal Investigator: Jeffrey Livas

CIRS-Lite

The Composite Infrared Spectrometer (CIRS) Fourier Transform Spectrometer (FTS) has returned important scientific results about the Saturnian system. As a result, the scientific community would like NASA to develop a follow-on, more capable FTS on the next outer-planet mission, especially if NASA chooses Titan. Any future instrument, however, must be smaller, lighter, and consume less power. In FY 2008, the CIRS-Lite team designed, built, and tested several critical instrument components to ultimately reduce the instrument's mass, volume, and power by factors of two or three. Principal Investigator: John Brasunas

GSFC technologists are using IRAD funds to develop technologies for a follow-on instrument to the highly successful Composite Infrared Spectrometer (CIRS) now flying on Cassini. That instrument has discovered remarkably high temperatures along fissures or tiger stripes (photo right) that cross Enceladus's south polar region.

Modeling of the South Pole Plasma Environment

Under this IRAD, principal investigators modeled dusty-plasma-surface interaction at the Moon's South Pole, specifically at the Aiken Basin. In addition to winning a NASA Announcement of Opportunity (see page 7 for details), the effort helped GSFC better define mission objectives for the Lunar Atmosphere and Dust Environment Explorer, which will launch in 2011 on a 100-day mission to study the Moon's atmosphere and ever-present dust. Principal Investigator: Bill Farrell

Asynchronous Laser Transponder for Highly Accurate Spacecraft Tracking at Planetary Distances

Several near-term missions likely will require highly accurate tracking and orbit determination provided by laser transponders. The principal investigator demonstrated single-photon asynchronous optical transponder capabilities, showing through independent analyses that ranging at Martian distances is very possible with existing lasers and relatively small apertures. The work also showed that the technology improved measurements of lunar and planetary motions by orders of magnitude. Principal Investigator: Philip Dabney

Chemical Processing Methodology

Scientists and engineers are better prepared to integrate large-scale laboratory methods into the design of small spaceborne devices, thanks to this IRAD that focused on developing an "in-line" chemical-processing method that combines some of the many different steps researchers use in laboratories on Earth to process and study organic compounds. The research applies to all planetary-analog investigations. Principal Investigator: Jennifer Eigenbrode

Goddard biogeochemist Jennifer Eigenbrode is using IRAD funds to develop a simplified sample-processing method that could be applied to a robotic chemistry lab.

Nanoscale Electric Field Sensor for a Mars Rover

Leveraging work performed under other R&D programs, the principal investigator successfully fabricated, packaged, and field-tested a nanoscale electric-field sensor needed to study environments characterized by large electric fields, such as thunderstorms and terrestrial and Martian dust storms. The sensor consists of a suspended network of single-walled carbon nanotubes that are clamped on both ends by thin-film electrodes. These nanotubes mechanically support a suspected metallic conductor. The technology could be applied to upcoming Mars missions as well as those to Jupiter, Saturn, Uranus, and Neptune. Principal Investigator: Stephanie Getty

Universal Chip Detector for Enhanced Organics Detection by Lab-on-a-Chip Liquid Chromatography

Advanced liquid processing will be critical to future missions that emphasize the search for biologically relevant organic molecules. Under this IRAD, the principal investigator used micro- and nano-fabrication methods to make components for a chemical field effect transistor (ChemFET), a low-power, highly sensitive detector for in situ analysis of liquids. The team developed and demonstrated several key enabling ChemFET components, providing a solid foundation for follow-on funding. Principal Investigator: Stephanie Getty

Flight Verification of GSFC Image Analysis Algorithms for Planetary Lander Missions

Teaming up with the Phoenix Mars lander project, the principal investigator verified three GSFC-developed image-analysis algorithms. Shortly after Phoenix landed on May 25, 2008, the team successfully used its algorithms to: (1) determine the best focus for the robotic arm's camera; (2) determine the as-landed point spread function of the surface stereo imager for high-fidelity image deconvolutions; and (3) measure dust particle sizes, distributions, and shapes. Principal Investigator: Brent Bos

Sealable Microleak for Mass Spectrometers

The sealable microleak is an urgently needed device to precisely control inlet flow rates for mass spectrometers currently under development at GSFC. Under this IRAD, the principal investigator is building a multi-channel microleak device that sequentially plugs channels and ensures a stable flow rate. Work will continue in FY 2009. Principal Investigator: Mary Li

Principal Investigator Brent Bos verified three GSFC-developed image analysis algorithms on the Phoenix Mars Lander shortly after the crafted landed on the Martian surface on May 25. He is pictured here with a model of the lander.

Thin-Film Dipole Array Development for Lunar and Spacecraft Radio Interferometry

Very low-mass antennas are a key element of all low-frequency radio observations from the Moon, which the science community has recognized as an ideal location for these observations. Under this IRAD, the principal investigators studied both potential designs for lightweight radio antennas deposited on polyimide film and the deployer to unroll them on the lunar surface. Principal Investigators: N. Gopalswamy and Robert MacDowall

Optimization of an Active Neutron Gamma-Ray Spectrometer for Planetary and Exploration Science

The goal of this IRAD was to study the geometric configuration for an active gamma-ray neutron instrument that could make bulk in situ abundance measurements of different elements on planetary surfaces. The principal investigator defined a detailed roadmap to further advance the technology and carried out field experiments. Principal Investigator: Ann Parsons

High-Resolution In situ-Remote Laser Spectrometer (HIRLS)

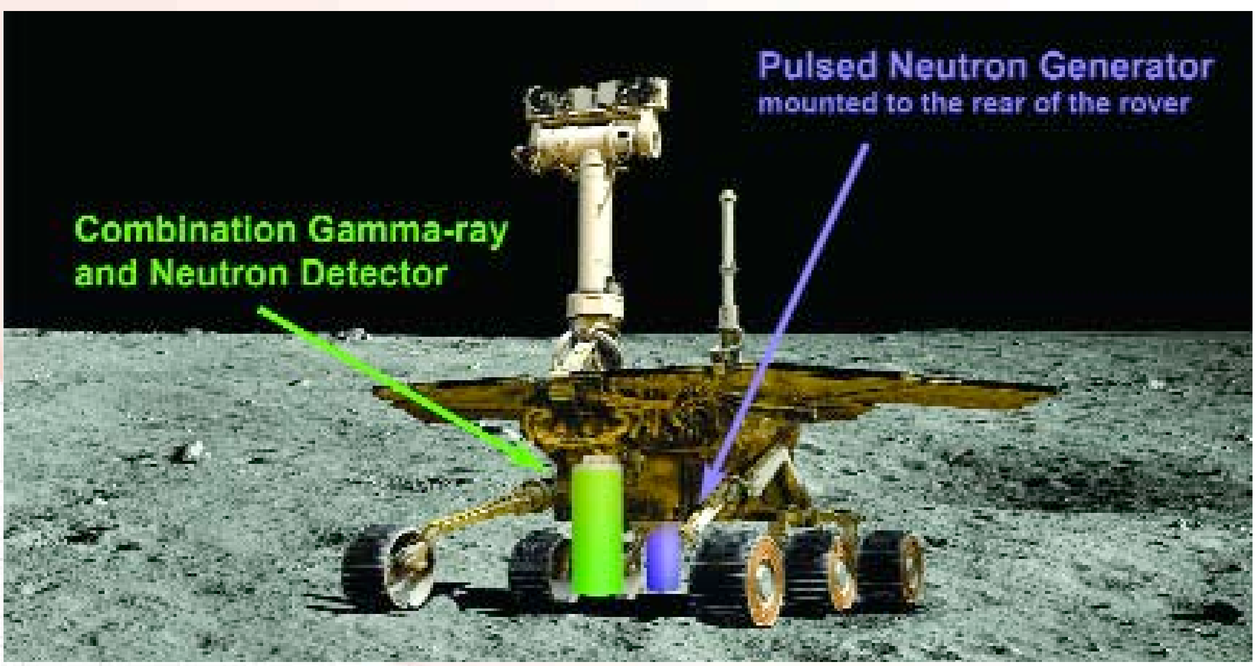
The principal investigator developed a breadboard instrument in his effort to ultimately create an extremely high-resolution spectrometer capable of probing composition, temperature, and planetary-atmosphere wind speeds in the 6-16 μm wavelength region. The next step is to develop a flight prototype, which if successful, would make GSFC more competitive in future proposals for both Earth observing and planetary missions. Principal Investigator: Theodor Kostiuk

A Portable Si-Drift-based X-ray Spectroscopy (XRS) Unit

This work combines two advanced technologies: a GSFC-built carbon-nanotube electron gun and a large-area silicon-drift detector to ultimately develop a miniaturized, portable X-ray spectrometer for planetary science and exploration missions. The instrument would be used to provide rapid, highly sensitive analyses of lunar and planetary rocks, soils, and ice. Work competed in FY 2008 is expected to position the team well for follow-on funding in FY 2009. Principal Investigator: Lucy Lim

2-D Array of Detectors with Gold Black Absorber

Imaging in the far infrared (IR) is important to several potential missions to the icy moons of Jupiter or Saturn Under this IRAD, the principal investigator developed a novel method for gold-black deposition on two-dimensional IR detectors. Gold black is often used an absorber in the far IR and remains the material of choice. At this point, NASA research funding will be needed to take the technology to the next logical step. Principal Investigator: Brook Lakew



If mounted to a rover, the active neutron gamma-ray spectrometer that GSFC scientist Ann Parsons is now developing could make bulk, in situ abundance measurements of different elements on planetary surfaces.

Strategic Crosscutting Technologies

Zero-Leak, One-Time-Use Valves for Propulsion System Applications

The focus of this IRAD was the design and test of a closed pyrovalve needed for chemical, in-space propulsion systems. Currently, only one manufacturer produces the component and its model has experienced misfires during ground tests. The principal investigator showed that her team's design could successfully actuate, raising her concept to a technology readiness level of four. Principal Investigator: Caitlin Eubank

Extreme Environment Low-Temperature ASICs for Telescope Readouts and Instrument Front-Ends

Application-specific integrated circuits (ASICs) cannot be designed without the use of transistor models to carry out simulations of circuit behavior and functionality. Low-temperature transistor models c u rrently are not available commercially. The principal investigator produced low-temperature "n-type" and "p-type" transistor model cards, which allowed her to develop a chip that she delivered for fabrication in September. Principal Investigator: La Vida Cooper

Principal Investigator La Vida Cooper is using IRAD funds to develop application-specific integrated circuits that can c a r ryout a specific electronic function in the forbidding space environment. In FY 2008, she produced low-temperature transistor models that allowed her develop a chip she delivered for fabrication.

Orbit Determination Toolbox

The Orbit Determination Toolbox is a Matlab-based analysis toolset that provides a more flexible way to carry out early mission analyses. Although needed for future mission development, GSFC already has used the toolbox to support several Phase-A studies. In FY 2008, the principal investigator added Tracking and Data Relay Satellite and generic lunar-relay measurement models to the toolbox, greatly enhancing the Center's analytical capabilities. Principal Investigator: Kevin Berry

Photon-Counting Laser Communication/Ranging System

The principal investigator is developing a low-cost testbed to simulate and develop photon-starved laser communications. In FY 2008, he demonstrated his testbed to the Science Mission and the Space Operations Mission Directorates, closing the gap with other organizations in this much-needed communications technology. Principal Investigator: Mike Krainak

Ultra-Weak GPS Signal Tracking

The principal investigator proposed to develop and implement a new signal-tracking algorithm capable of tracking signals at 15 dB-Hz. Though he did not accomplish the main objectives, he did mature the software receiver to raise the technology maturity level of the Magentospheric Multiscale Mission's Inter-Spacecraft Ranging and Alarm System. Additionally, the technology will be the basis of a low-cost GPS receiver, Navigator Lite™, used by the Wallops Flight Facility. Principal Investigator: Gregory Heckler

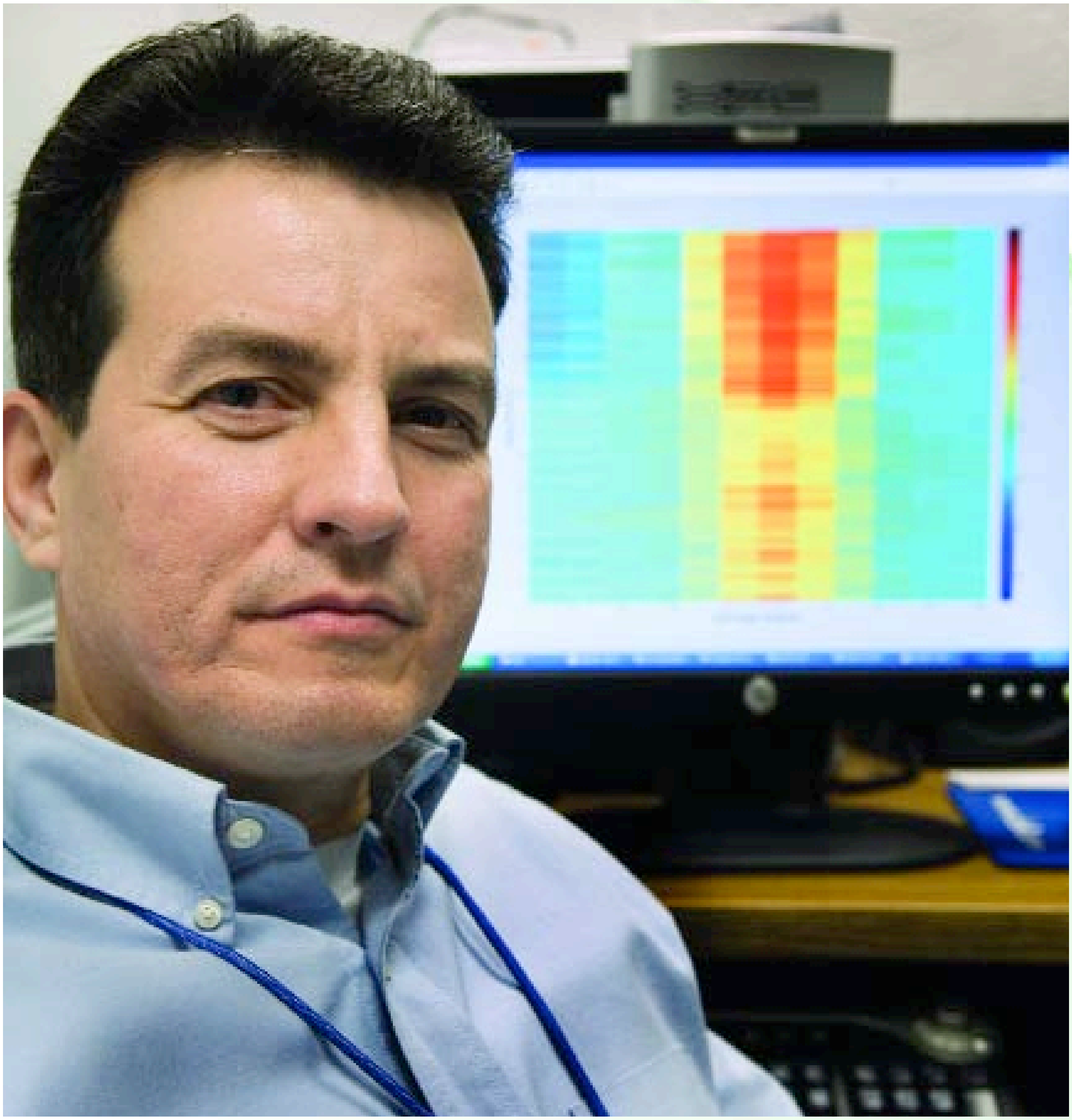
HgCdTe Avalanche Photodiodes for Precision Surface Laser Altimeter Applications

Mercury-cadmium-telluride (HgCdTe) detectors are more efficient, offer higher gain, and lower excess noise than silicon avalanche photodiodes. Although they have flown on astronomical missions, all space-borne laser altimeters to date have used silicon. Under this IRAD, the principal investigator verified that the HgCdTe detectors would provide the gain and bandwidth needed for future Earth-observing missions. He also acquired test equipment and assembled a test setup to evaluate the technology for the lidar community. Principal Investigator: Xiaoli Sun

Navigator is a space-qualified Global Positioning System receiver designed to work in weak-signal environments. In FY 2008, principal investigators reduced the technical risk of key components, leveraging investments to develop a flight version for the Global Precipitation Measurement mission.

Navigator GPS

Navigator is a space-qualified Global Positioning System receiver designed to work in weak-signal environments, specifically those found in highly elliptical or geosynchronous orbits. Already slated to fly on the Magnetospheric Multiscale Mission as part of the Inter-Spacecraft Ranging and Alarm System, the principal investigator reduced the technical risk of key components in FY 2008, leveraging investments to develop a flight version for the Global Precipitation Measurement mission. The principal investigator is marketing the Navigator to potential Constellation Program users. Principal Investigator: John.C.Adams



Principal Investigator Rafael Rincon flight-tested for the first time GSFC's Digital Beamforming Synthetic Aperture Radar in FY 2008. He is now evaluating the data taken during the campaign.

Flash Lidar

GSFC is now working to demonstrate a three-dimensional flash lidar capable of precise ranging, altimetry, and imaging — capabilities that NASA needs to locate obstacles during landing, carry out autonomous docking maneuvers on the Moon, and avoid hazards while navigating the surface. In FY 2008, the principal investigator completed up-front work and designed and laid out an application-specific integrated circuit to interface with a silicon avalanche photodiode detector array. Principal Investigator: Anthony Yu

Onboard Digital Beamforming Radar Techniques

The principal investigator flight-tested for the first time GSFC's Digital Beamforming Synthetic Aperture Radar (DBSAR), a technology that could enable reconfigurable, multi-mode measurements in a single radar system and dramatically improve Earth and planetary science observations. The team is currently evaluating data taken during the campaigns. Principal Investigator: Rafael Rincon

Looking Ahead in FY 2009

It remains to be seen whether FY 2009 proves as successful as FY 2008 in attracting follow-on funding and new mission opportunities. Based on the number of awards already announced and the number of proposals submitted early in FY 2009, we might enjoy another banner year, again underscoring the wisdom of aligning our program to the Center's core lines of business and already-identified mission opportunities.

However, investing in longer-term, higher-risk technologies also has its merits, and in fact, has led to important mission-enabling successes. The microshutter detector array that is flying on the James Webb Space Telescope and the curved mirrors that GSFC now is manufacturing for the Nuclear Spectroscopic Telescope are just a few high-risk technologies that the Center funded and resulted in mission opportunities.

In FY 2009, the IRAD program invested a greater percentage of its resources in these longer-term technologies. The Office of Chief Technologist is encouraging innovators to propose forward-looking technologies that align with the Center's core business areas and offer the potential for significant leaps in capability.

By maintaining a balanced program of nearer- and farther-term investments, together we can maintain GSFC's competitive edge and provide the Agency with technologies it needs to carry out world-class missions that enlighten and inspire the world.

The highlight of the year is the Annual IRAD Poster Session, which showcases the successes of the year's investments. In the photo above, Center Director Rob Strain talks with Chief Technologist Peter Hughes (right), Deputy Chief Technologist Deborah Amato (foreground), and IRAD Innovator of the Year Richard Kelley.

Mike Johnson (left) talks with Bill Farrell about his work to characterize the dusty plasma on the Moon.